Quantifying Tremor and Motor Dysfunction Associated with Alcohol Intoxication

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Introduction

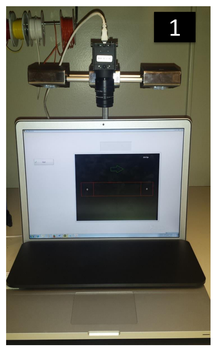
Excessive alcohol consumption can result in severe personal and societal consequences, costing individuals over 30 years of potential life and the nation over $220 billion annually[1]. Recent drug treatments have targeted the symptoms that are often associated with excessive alcohol consumption including tremor, motor dysfunction, and craving. One such drug, baclofen, a GABA-receptor agonist, has been shown to reduce alcohol craving and intake in alcohol-dependent individuals. Though Baclofen's effects have been shown qualitatively (i.e. through the use of post-study questionnaires and reduced drinking habits), its quantitative effects on motor function are not fully understood[2].

The camera system developed in this project was designed to quantitatively measure such motor dysfunction in patients enrolled in a clinical trial in the NIAAA. Patients are instructed to follow a series of pre-defined hand motions, with real-time feedback indicating any significant deviation from the desired motion. Post-analysis of the video provides quantitative indications of any tremor or motor dysfunction. The system's performance and reliability was ultimately evaluated using a group of control subjects.

Hardware Design

In order to effectively detect motor dysfunction in patients in the NIAAA "Bar" clinic, the hardware portion of the system required four major components – a screen that could host the user interface, a camera to record motion and detect any potential anomalies, an LED to provide uniform lighting for the image, and a mount to hold all of these pieces in place.

Figure 1 shows the overall hardware system design. As can be seen, a camera and LED system hangs over a laptop computer. All components are mounted to an acrylic base (the computer with velcro and the camera with square aluminum posts and magnets).



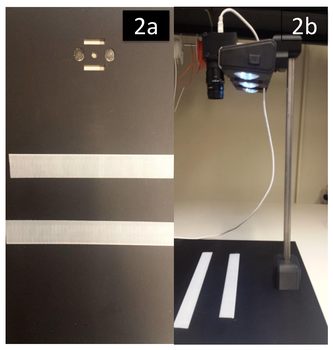
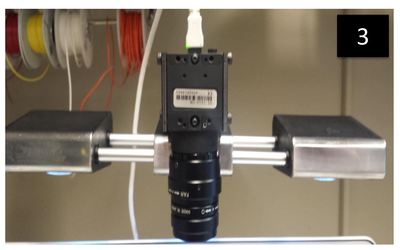


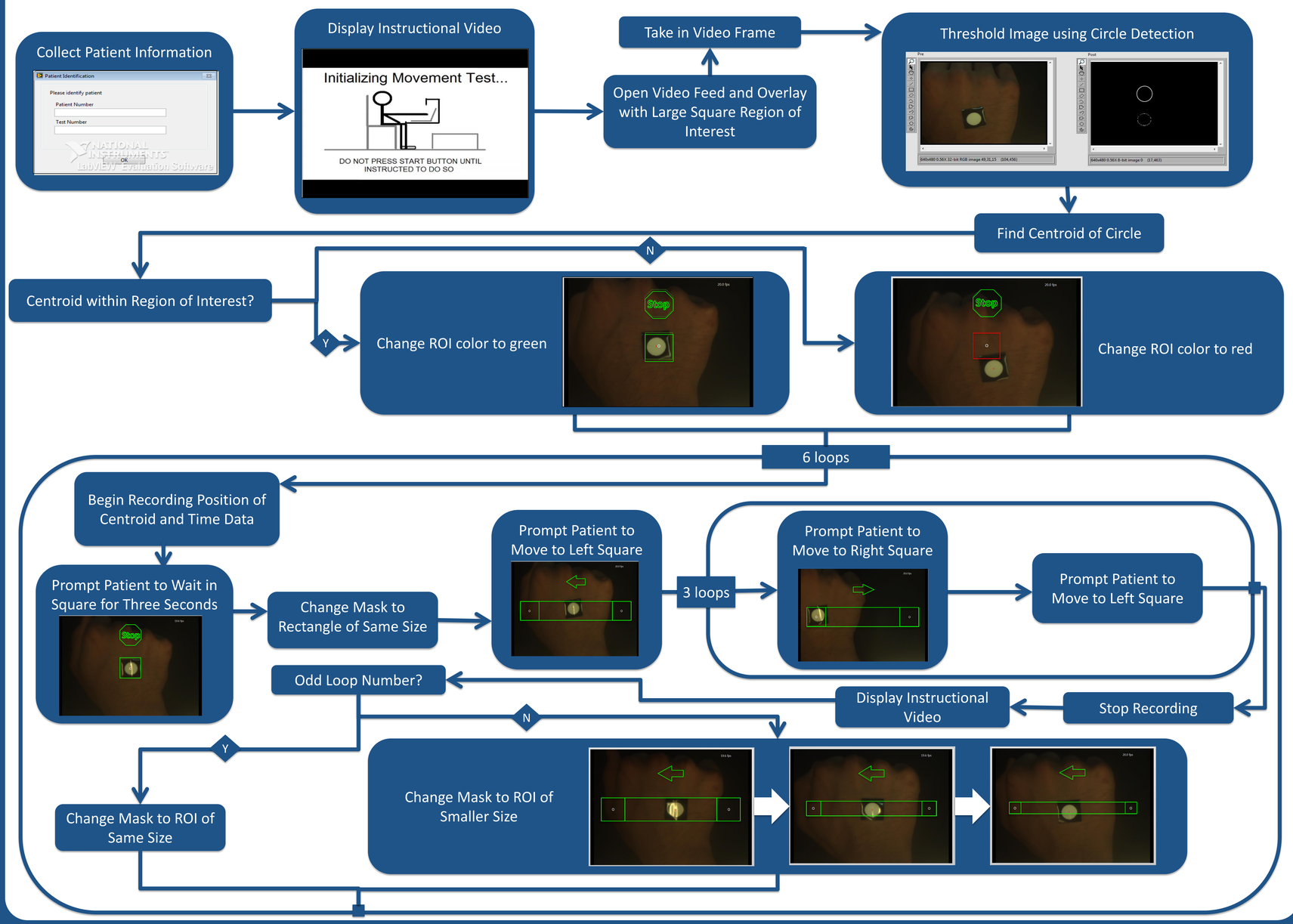
Figure 2a exhibits the mount for the other components in the system. The base is made of acrylic with velcro to mount the computer and slots/magnets to hold the camera post in place. Figure 2b show the post with custom 3-D printed joints and square aluminum posts to hold the camera and LED in the correct position

Figure 3 displays the camera/LED system. A uEye imaging camera (UI-1410-C, IDS Image Developing Solutions, Inc., Obersulm, Germany), mounted above a laptop was used due to its high spatial resolution. A commercially available LED (Grilluminate CGL-330, Cuisinart, Stamford, CT) light system provides uniform lighting for thresholding purposes in motion detection. The LED mount was modified to interface with our system.



Software Design

The software for this system was designed to completely automate a motor function test that could interface with the NIAAA's current protocol in studying baclofen's effects on the behavior of non-treatment seeking, anxious alcoholics. The LabView program was designed to track a white sticker on the users' hand as he/she moved his/her hand in a predefined manner under the uEye camera. During this time, the software actively collected video, thresholded the video according to luminance value, detected circles in the thresholded, grayscale image (to rid it of any bright objects from skin tone), and found the centroid of this circle on the sticker. Predefined regions of interest were then overlain on the video feed, and the position of the centroid was compared to the location of the ROI. If the centroid was inside the ROI, the ROI remained green; if it was outside, the ROI turned red. As the test proceeded, the ROI became progressively smaller. The position and time data collected during the test were then used to calculate a few metrics to determine any effects alcohol intoxication and baclofen treatment might have on motor function. The following flowchart presents the logic behind the software:



Results

Four metrics were extracted from the x-y centroid data:

1) the excess distance the patient covered; in other words, the linear distance between the two endpoints subtracted from the total distance traveled,
2) the speed with which they moved in each direction,
3) the number of times their hand left the region of interest,
4) the amount of time they spent outside the region of interest.

Ideally, these values could be used to distinguish between a group treated with baclofen and a group treated with placebo. The graphs below display control patient data, and two general trends can be observed. The excess distance and average x-velocity for each patient remained relatively constant throughout the tests; however, both the number of errors they made and the duration of those errors decreased.

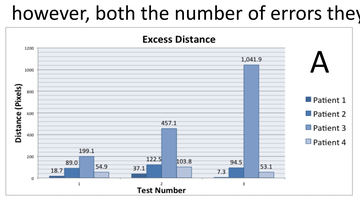


Figure A displays the excess distance (in pixels) that the patient traveled in the last three tests of the procedure. Each patient had a similar excess distance across all tests except Patient 3 whose third test had a significantly higher value. This can be explained by Patient 3 intentionally simulating motor dysfunction in this test to determine the robustness of the tracking algorithm.

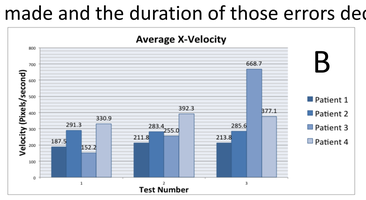


Figure B displays the average x-velocity (in pixels per second) of the patient during the last three tests of the procedure. As with Figure A, each patient had a similar velocity across all tests except Patient 3 who, in the third test, intentionally simulated a motor dysfunction.

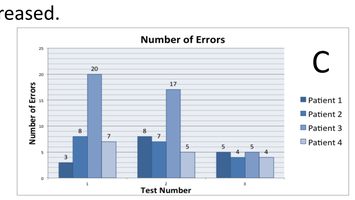


Figure C displays the number of errors made by each patient during the last three tests of the procedure. As expected, as the patient became more familiar with the system after a few tests, the number of errors they committed decreased.

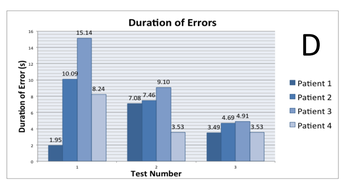


Figure D displays the duration of errors made by each patient during the last three tests of the procedure. Just as with figure C, when the patient became more familiar with the system, the time they spent outside of the ROI decreased.

Conclusion/Future Work

Conclusion

-Hardware was successfully and inexpensively installed within the current NIAAA lab setup.
-Software was automated and appropriately adjusted to provide a friendly user interface and to collect a large amount of data that can be further processed.
-Four major metrics were automated in Matlab for post-processing of videos to quantify motor dysfunction.
-Preliminary control data showed that distance and velocity remain constant across tests, while number and duration of errors decreases. Deviation from these trends might suggest some motor dysfunction.

Future Work

-Collect patient data in the NIAAA bar lab to modify metrics targeted to extract valuable data.
-Develop algorithm for robust calculation of tremor frequency.
-Configure calibration algorithm so thresholding parameters can be adjusted based on lighting conditions.

References

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